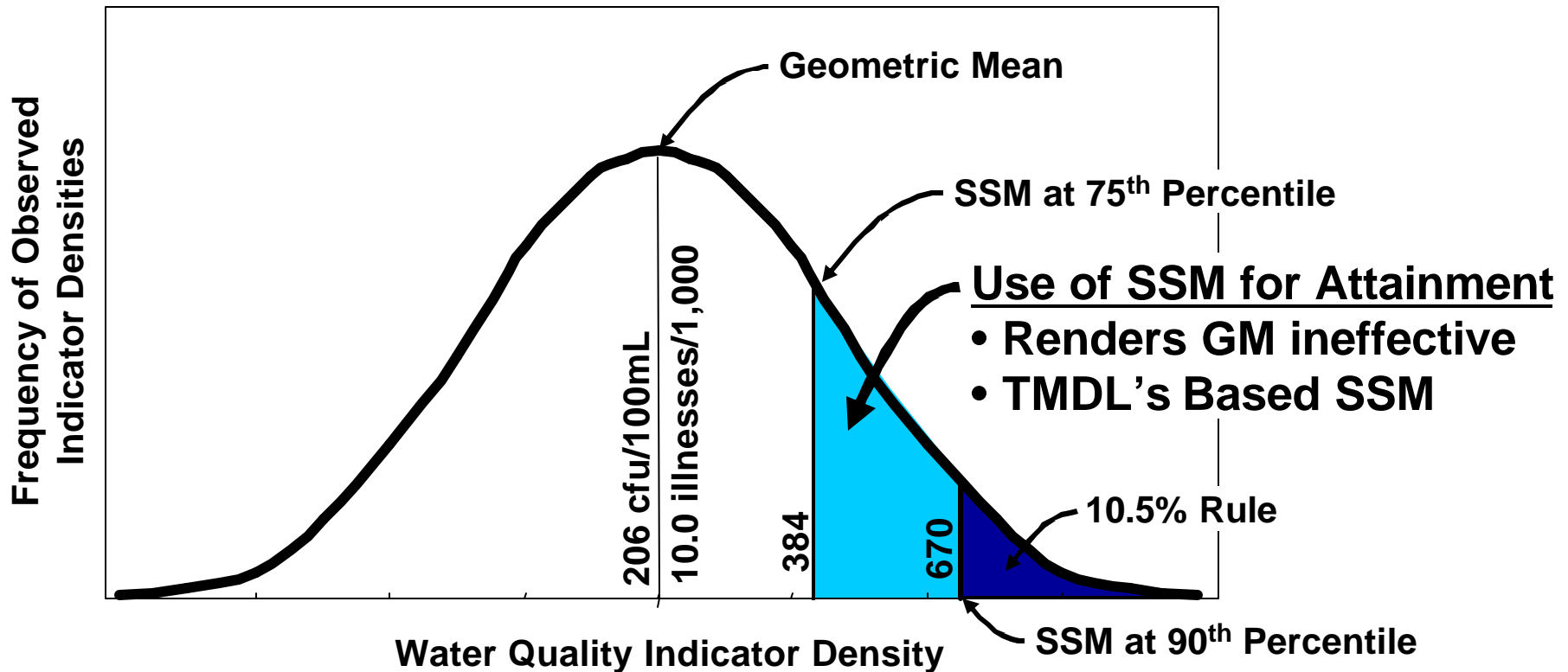




Use of Single Sample Maximum Current Water Quality Standards

Distribution Around Mean

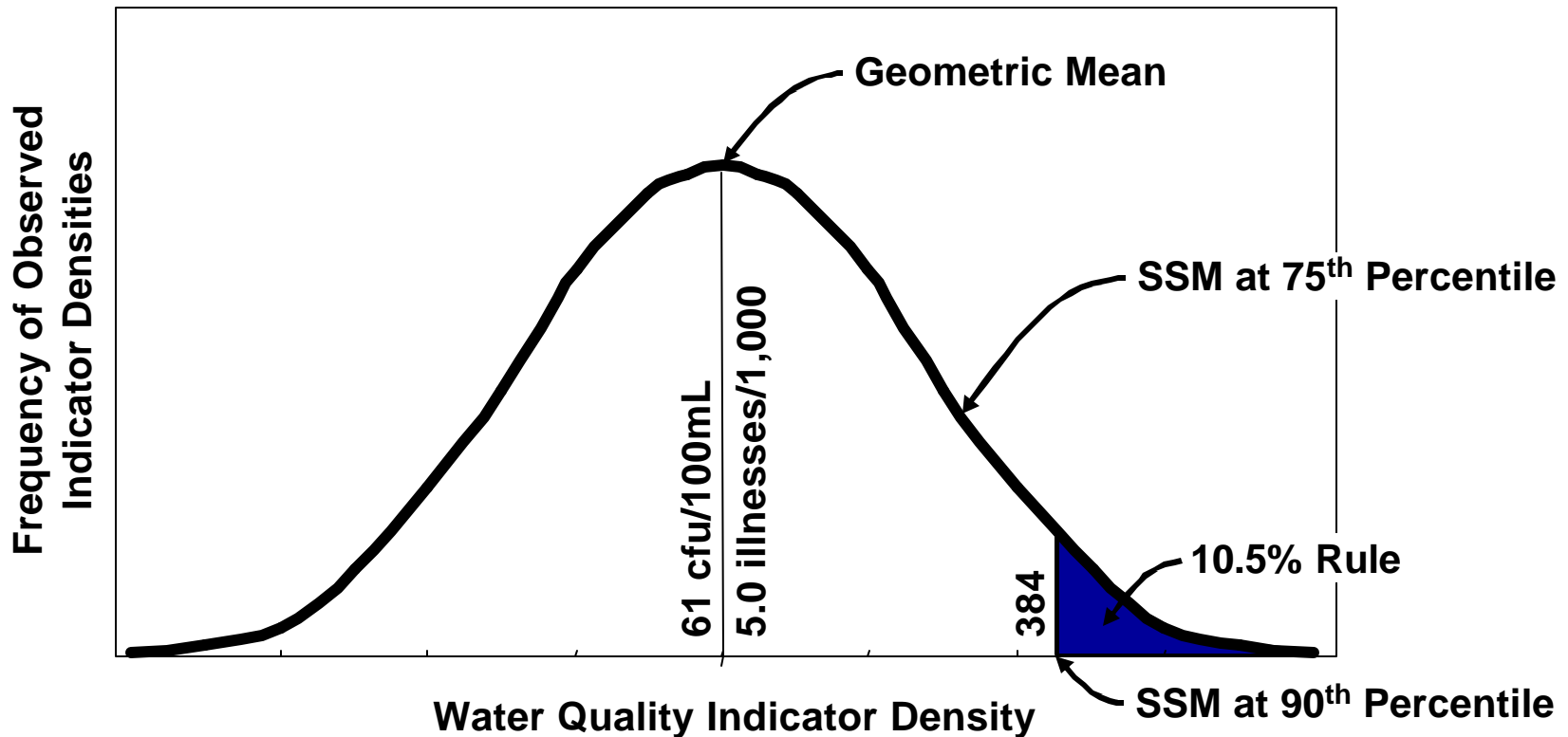




Use of Single Sample Maximum

Example with Richmond Area Log Standard Deviation

Distribution Around Mean





Water Quality Model Output: Alternative E

E-Coli - Monthly Geometric Mean (#/100ml)																					
Year	Month	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		98.9	97.8	96.8	95.8	94.8	93.8	92.8	91.8	90.8	89.8	88.8	87.8	86.8	85.8	84.8	83.8	82.8	81.8	80.8	79.8
Avg 74-78	Jan	56	66	69	68	66	66	73	79	80	78	77	75	73	71	68	65	63	60	58	57
	Feb	53	58	60	59	58	58	62	65	65	63	62	61	60	59	57	55	53	52	50	48
	Mar	56	64	67	66	64	66	74	80	82	80	78	77	76	74	72	69	67	65	63	62
	April	87	91	93	92	89	89	93	98	98	95	94	92	91	89	87	85	83	80	79	77
	May	124	137	145	145	142	143	155	167	168	162	156	149	142	134	125	117	110	104	99	95
	June	113	123	129	128	125	126	135	145	146	141	135	129	124	118	111	106	100	94	90	87
	Jul	112	124	130	126	118	119	131	142	141	132	122	113	105	97	87	79	73	67	64	61
	Aug	160	182	193	189	178	177	189	201	199	188	174	161	151	140	129	118	109	102	97	92
	Sept	74	83	87	84	80	83	94	104	105	98	92	87	84	78	72	66	61	59	57	55
	Oct	80	89	92	89	82	81	87	94	92	87	81	75	72	66	60	55	51	48	46	45
	Nov	83	91	94	89	82	81	87	92	91	84	78	72	67	62	57	52	48	45	43	42
	Dec	72	86	95	96	94	96	106	115	117	114	111	108	106	102	97	92	87	82	78	75

Illness Rate per 1,000 Swimmers based on E-Coli - Monthly Geometric Mean																					
Year	Month	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		98.9	97.8	96.8	95.8	94.8	93.8	92.8	91.8	90.8	89.8	88.8	87.8	86.8	85.8	84.8	83.8	82.8	81.8	80.8	79.8
Avg 74-78	Jan	4.7	5.3	5.6	5.5	5.4	5.4	5.8	6.1	6.2	6.1	6.0	5.9	5.8	5.7	5.5	5.3	5.1	5.0	4.8	4.7
	Feb	4.5	4.8	5.0	4.9	4.8	4.9	5.1	5.3	5.3	5.2	5.1	5.1	5.0	4.9	4.8	4.6	4.5	4.4	4.2	4.1
	Mar	4.7	5.2	5.4	5.4	5.3	5.4	5.8	6.2	6.2	6.1	6.0	6.0	5.9	5.8	5.7	5.6	5.4	5.3	5.2	5.1
	April	6.5	6.7	6.8	6.7	6.6	6.6	6.8	7.0	7.0	6.9	6.8	6.7	6.7	6.6	6.5	6.4	6.3	6.2	6.1	6.0
	May	7.9	8.3	8.6	8.6	8.5	8.5	8.9	9.2	9.2	9.0	8.9	8.7	8.5	8.3	8.0	7.7	7.5	7.2	7.0	6.8
	June	7.6	7.9	8.1	8.1	8.0	8.0	8.3	8.6	8.6	8.5	8.3	8.1	7.9	7.7	7.5	7.3	7.0	6.8	6.7	6.5
	Jul	7.5	8.0	8.1	8.0	7.7	7.8	8.2	8.5	8.5	8.2	7.9	7.6	7.3	6.9	6.5	6.1	5.8	5.4	5.2	5.0
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	Sept	5.8	6.3	6.5	6.3	6.1	6.3	6.8	7.2	7.2	7.0	6.7	6.5	6.3	6.0	5.7	5.4	5.1	4.9	4.8	4.6
	Oct	6.2	6.6	6.7	6.6	6.3	6.2	6.5	6.8	6.7	6.5	6.2	5.9	5.7	5.4	5.0	4.7	4.3	4.1	3.9	3.8
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	Dec	5.7	6.4	6.8	6.9	6.8	6.9	7.3	7.6	7.7	7.6	7.5	7.4	7.3	7.2	7.0	6.7	6.5	6.3	6.1	5.9





Use of Single Sample Maximum

Example with Richmond Area Log Standard Deviation

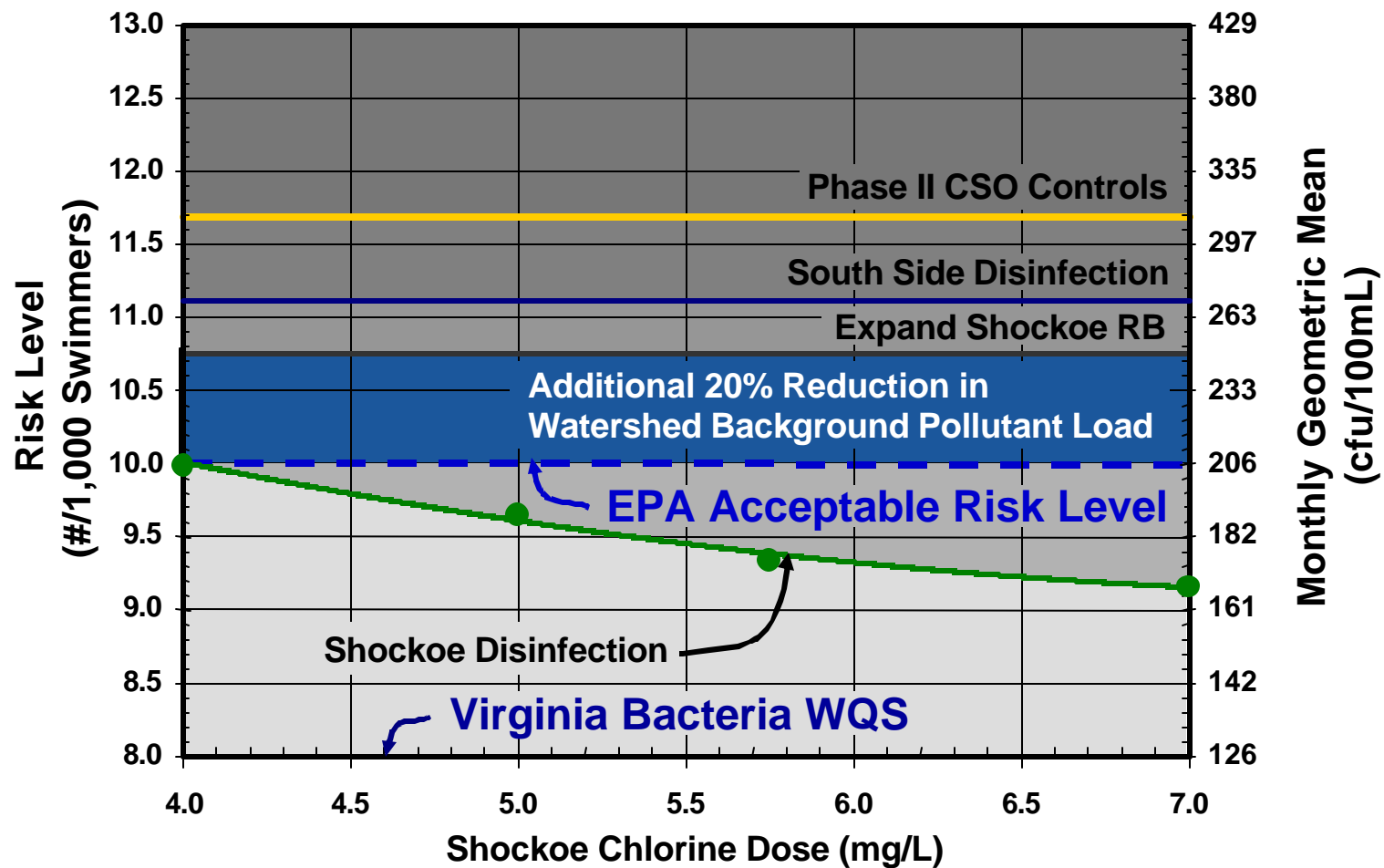
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	June	7.6	7.9	8.1	8.1	8.0	8.0	8.3	8.6	8.6	8.5	8.3	8.1	7.9	7.7	7.5	7.3	7.0	6.8	6.7	6.5
	Jul	7.5	8.0	8.1	8.0	7.7	7.8	8.2	8.5	8.5	8.2	7.9	7.6	7.3	6.9	6.5	6.1	5.8	5.4	5.2	5.0
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	Oct	6.2	6.6	6.7	6.6	6.3	6.2	6.5	6.8	6.7	6.5	6.2	5.9	5.7	5.4	5.0	4.7	4.3	4.1	3.9	3.8
	Nov	6.3	6.7	6.8	6.6	6.3	6.2	6.5	6.7	6.7	6.4	6.0	5.7	5.4	5.1	4.7	4.4	4.1	3.8	3.6	3.5
	Dec	5.7	6.4	6.8	6.9	6.8	6.9	7.3	7.6	7.7	7.6	7.5	7.4	7.3	7.2	7.0	6.7	6.5	6.3	6.1	5.9





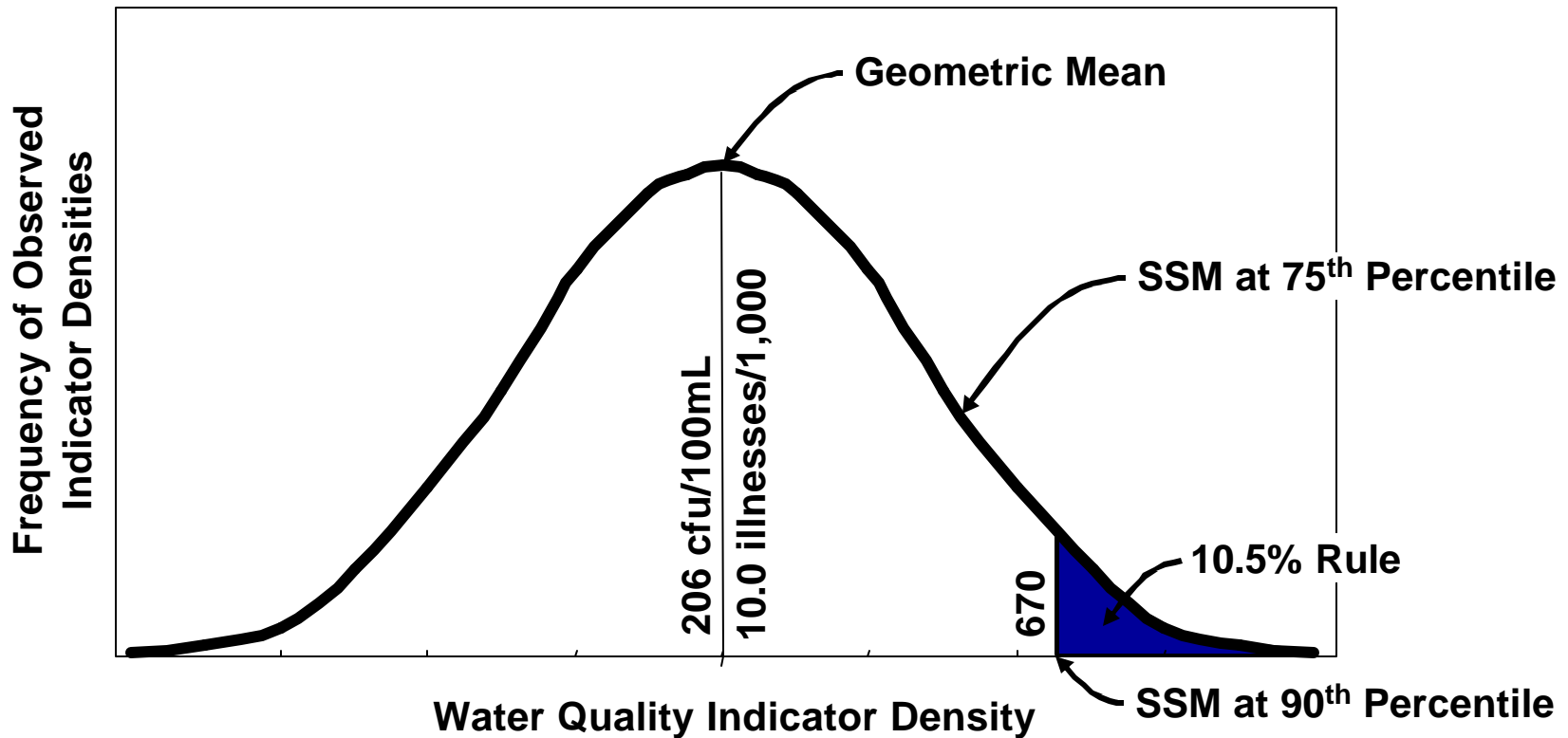
Shockoe Chlorine Facility Performance: James River Reach 13 for August





Use of Single Sample Maximum Recommend SSM at 90th Percentile

Distribution Around Mean





EPA Excerpts

- Geometric Mean Best Indicator for Long Term Water Quality Conditions (Especially Chronic Pollution)
- Use of Single Sample Maximum (from Beach Act 2004)
 - “the single sample maximum values in the 1986 bacteria criteria document were not developed as acute criteria; rather, they were developed as a statistical construction to allow decision makers to make informed decisions to open or close beaches based on small data sets. This does not mean single sample maximums serve no purpose outside of beach notification decisions. For example, they may give States and Territories the ability to make waterbody assessments where they have limited data for a waterbody. However, the single sample maximums were not designed to provide a further reduction in the design illness level provided for by the geometric mean criterion”
 - “If that single sample maximum were used as a value-not-to-be-surpassed, it would become a maximum value and all other values in the statistical distribution of individual measurements would have to be less than the maximum. EPA typically uses the 99th percentile of a distribution to derive regulatory maximums.”



Bacteriological Water Quality Standards

Summary

- EPA Recommends Geometric Mean for Attainment Decisions
- If SSM used for attainment decisions & development of WLA in TMDL process
 - SSM should be based on 90th Percentile (FW 670 & Marine 275 cfu/100mL) with 10.5% rule, which is equivalent to Geometric Mean bacteria criterion
 - Site specific standard deviation should remain in water quality standard to maintain relationship with Geometric Mean (EPA indicates that GM better indicator for long-term health of water body)





GREELEY AND HANSEN

Discussion



Water Quality Standards for Coastal and Great Lakes Recreation Waters; Final Rule (Beach Act 11/16/2004)

Bacteriological Water Quality Standards

Freshwater Primary Contact Recreation					
Illness Rate (per 1000)	Geometric Mean Density	Designated Beach Area 75% C.L.	Moderate Full Body Contact Recreation 82% C.L.	Lightly Used Full Body Contact 90% C.L.	Infrequently Used Full Body Contact 95% C.L.
8	126	235	298	410	576
10	206	384	487	670	942

Saltwater and Transition Zone Primary Contact Recreation					
Illness Rate (per 1000)	Geometric Mean Density	Designated Beach Area 75% C.L.	Moderate Full Body Contact Recreation 82% C.L.	Lightly Used Full Body Contact 90% C.L.	Infrequently Used Full Body Contact 95% C.L.
19	35	104	158	275	500





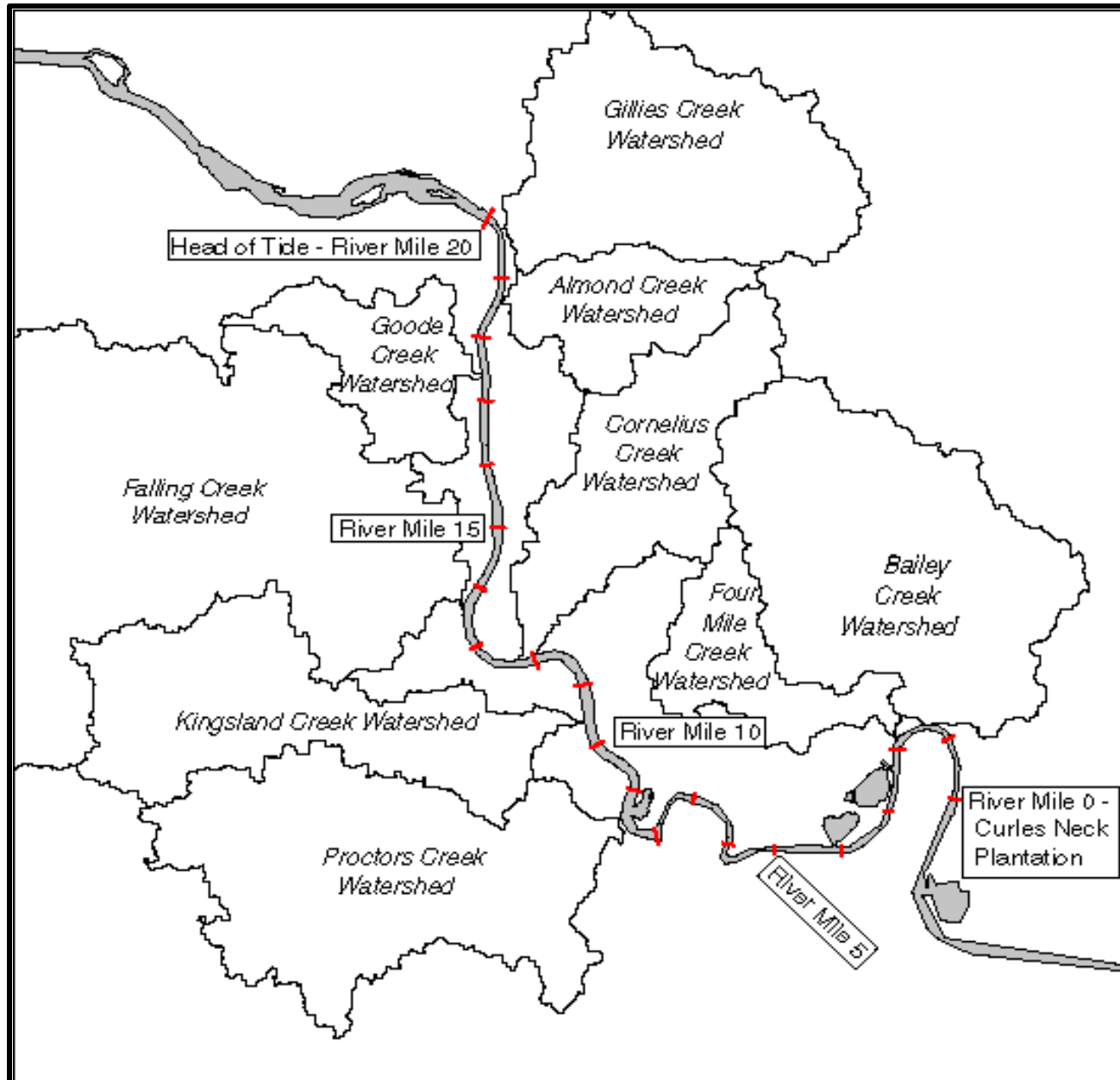
Water Quality Standards for Coastal and Great Lakes Recreation Waters; Final Rule (Beach Act 11/16/2004)

Definitions from Final Rule

- **Designated Bathing Beach Waters:** "Designated bathing beach waters are those coastal recreation waters that, during the recreation season, are heavily-used (based upon an evaluation of use within the State) and may have: a lifeguard, bathhouse facilities, or public parking for beach access. States may include any other waters in this category even if the waters do not meet these criteria."
- **Moderate Full Body Contact Recreation:** "Moderate use coastal recreation waters are those coastal recreation waters that are not designated bathing beach waters but typically, during the recreation season, are used by at least half of the number of people as at typical designated bathing beach waters within the State. States may also include light use or infrequent use coastal recreation waters in this category."
- **Lightly Used Full Body Contact:** "Light use coastal recreation waters are those coastal recreation waters that are not designated bathing beach waters but typically, during the recreation season, are used by less than half of the number of people as at typical designated bathing beach waters within the State, but are more than infrequently used. States may also include infrequent use coastal recreation waters in this category."
- **Infrequently Used Full Body Contact:** "Infrequent use coastal recreation waters are those coastal recreation waters that are rarely or occasionally used."



Downstream Watershed Delineations





EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

History – Initial WQ Criteria

- Epidemiological Studies Conducted in 1940's & 1950's by US Public Health Service
- First Water Quality Criteria
 - Proposed by National Technical Advisory Committee (NTAC) in 1968
 - Studies show significant illnesses at total coliform of 2300 cfu/100ml
 - Fecal coliform found to be about 18% of total coliform
 - Fecal coliform levels greater than 400 cfu/100ml would show significant illnesses
 - NTAC recommended fecal coliform as indicator
 - 30-day geometric mean of 200 cfu/100ml (half of 400 cfu/100ml)
 - 10% samples in 30-days not greater than 400 cfu/100ml





EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

History – Initial WQ Criteria (Continued)

- EPA Recommend This Criterion Again in 1976
- Weakness of Early Epidemiological Studies Identified
 - Questioned data behind WQS for FC 200 GM
 - Calendar Method: Lumped illnesses from clean days with those from high coliform days
 - Swimming poorly defined
 - Did not ask if participant immersed their bodies or even if they submerged their heads
 - FC indicator includes thermo-tolerant *Klebsiella* species, which do not indicate the presence of fecal contamination



EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

History – 1986 Guidance

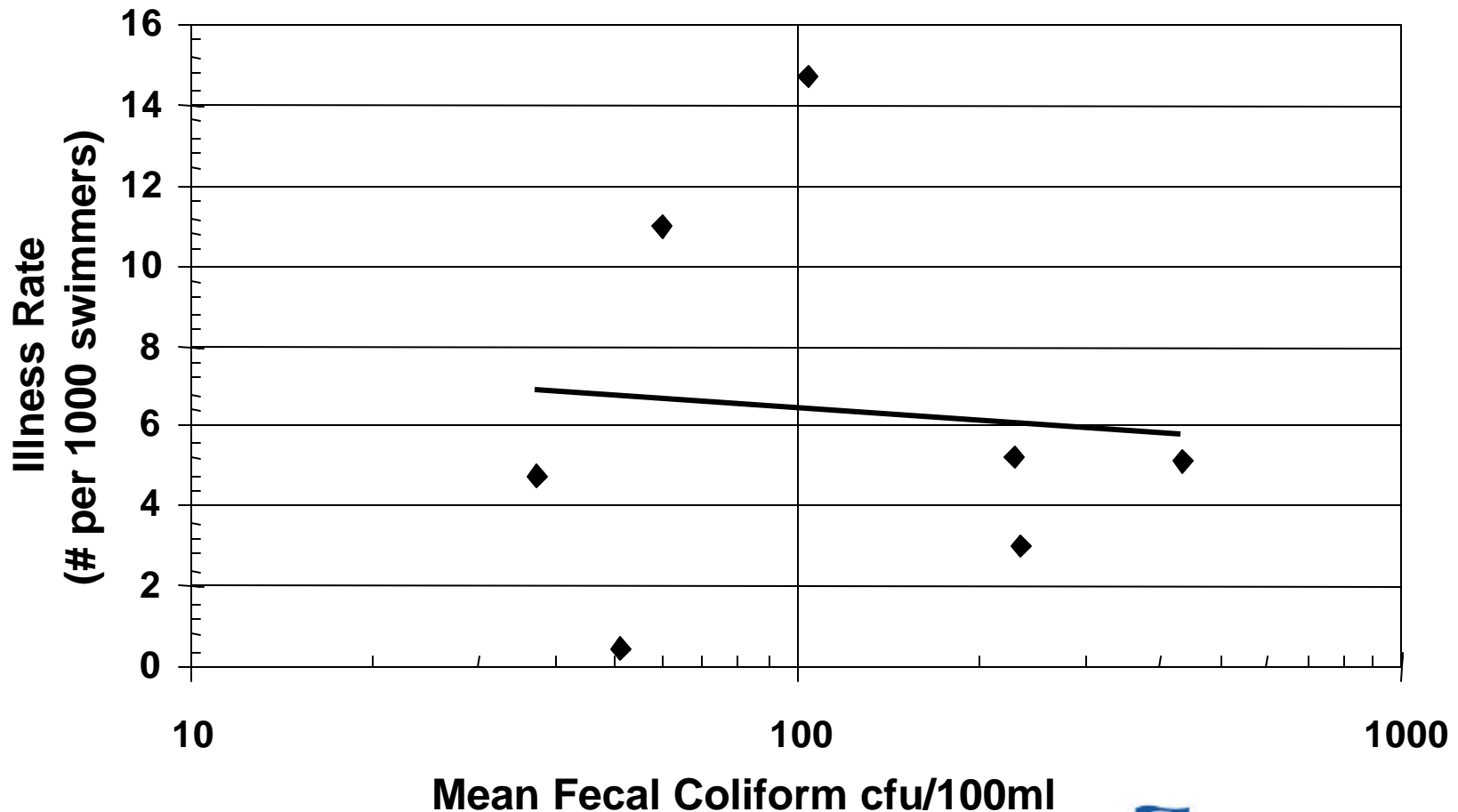
- EPA Initiated Series of Studies in 1972
 - Designed to correct perceived deficiencies of earlier studies
 - Focused on fresh & marine water bathing beaches
- Epidemiological Surveys
 - Weekends only & excluded participants who swam mid-week
 - Included four general symptom categories
 - Various indicators used to determine best correlation in fresh & marine waters
 - Focused on beaches with low & high bacteria counts



EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

History – 1986 Guidance (Continued)

Fecal Coliform Indicator in Freshwater

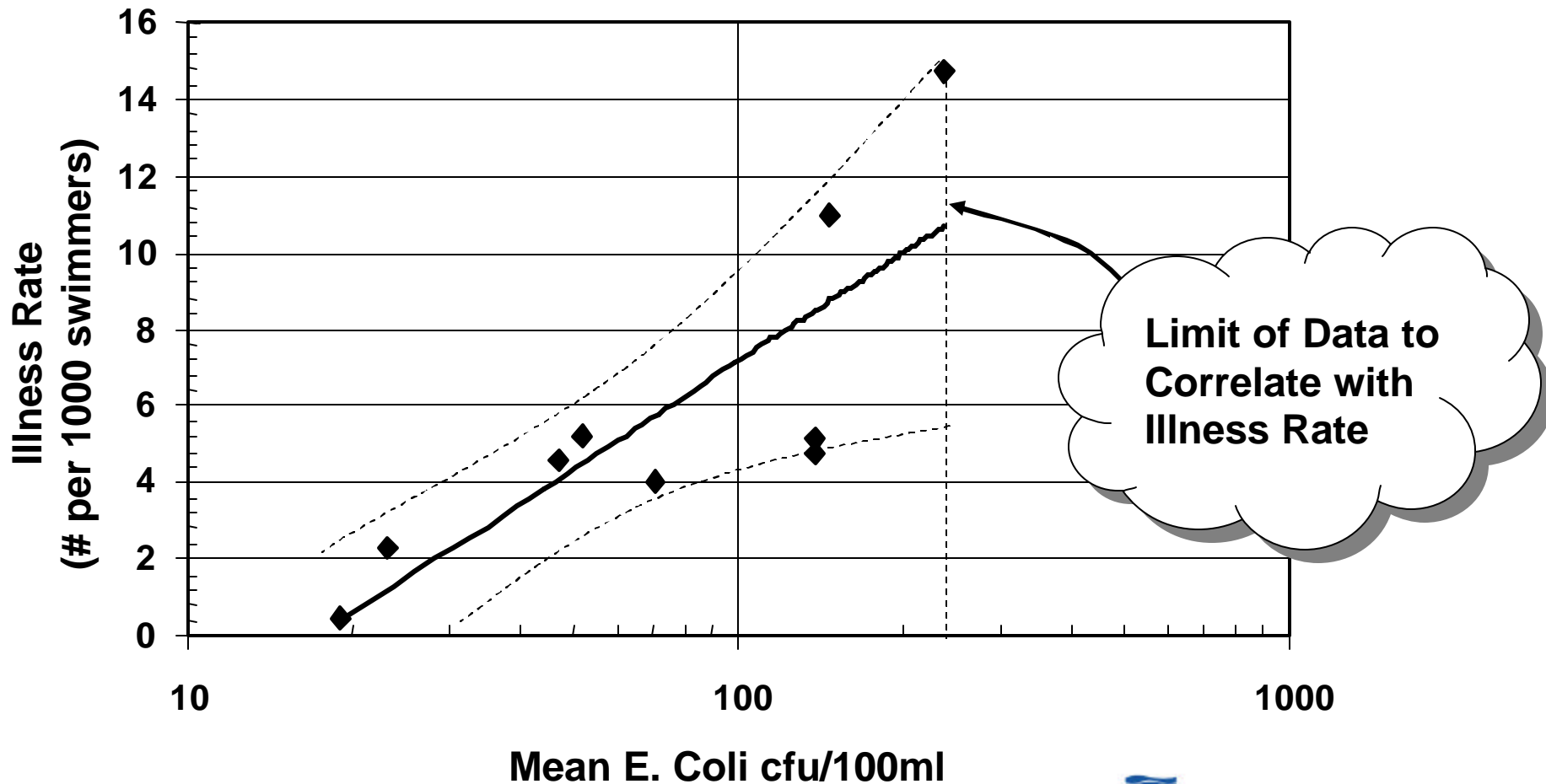




EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

History – 1986 Guidance (Continued)

E.Coli Indicator in Freshwater





EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

November 2003 Draft Guidance (Continued)

- Historical acceptable risk levels estimated to be about 0.8% of swimmers at fresh water beaches
 - Based on ratios of fecal coliform to E. coli
 - EPA stated in 1986 Guidance regarding FC WQS
 - "While this [risk] level was based on the historically accepted risk, it is still arbitrary insofar as the historical risk was itself arbitrary."
- "EPA recommends that states and authorized tribes adopt fresh water criteria based on risk levels at or below 1.0%"



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EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

November 2003 Draft Guidance (Continued)

- **"Single Sample Maximum"**
 - Never Intended to be "Value not to Exceed"
Regarding Attainment Decisions
 - Daily exposure statistically related to GM
- **Geometric Mean Best Indicator for Long Term Water Quality Conditions (Especially Chronic Pollution)**





EPA's Implementation Guidance for Ambient Water Quality Criteria for Bacteria

November 2003 Draft Guidance (Continued)

- **Single Sample Maximum**
 - Primary use: Beach Monitoring
 - Best predictor of today's condition would be yesterday's measurement alone & greater period between measurements, the less their predictive value (USEPA, 2003)
- **Risk Management Decisions**
 - Issue public warnings
 - Close the beach

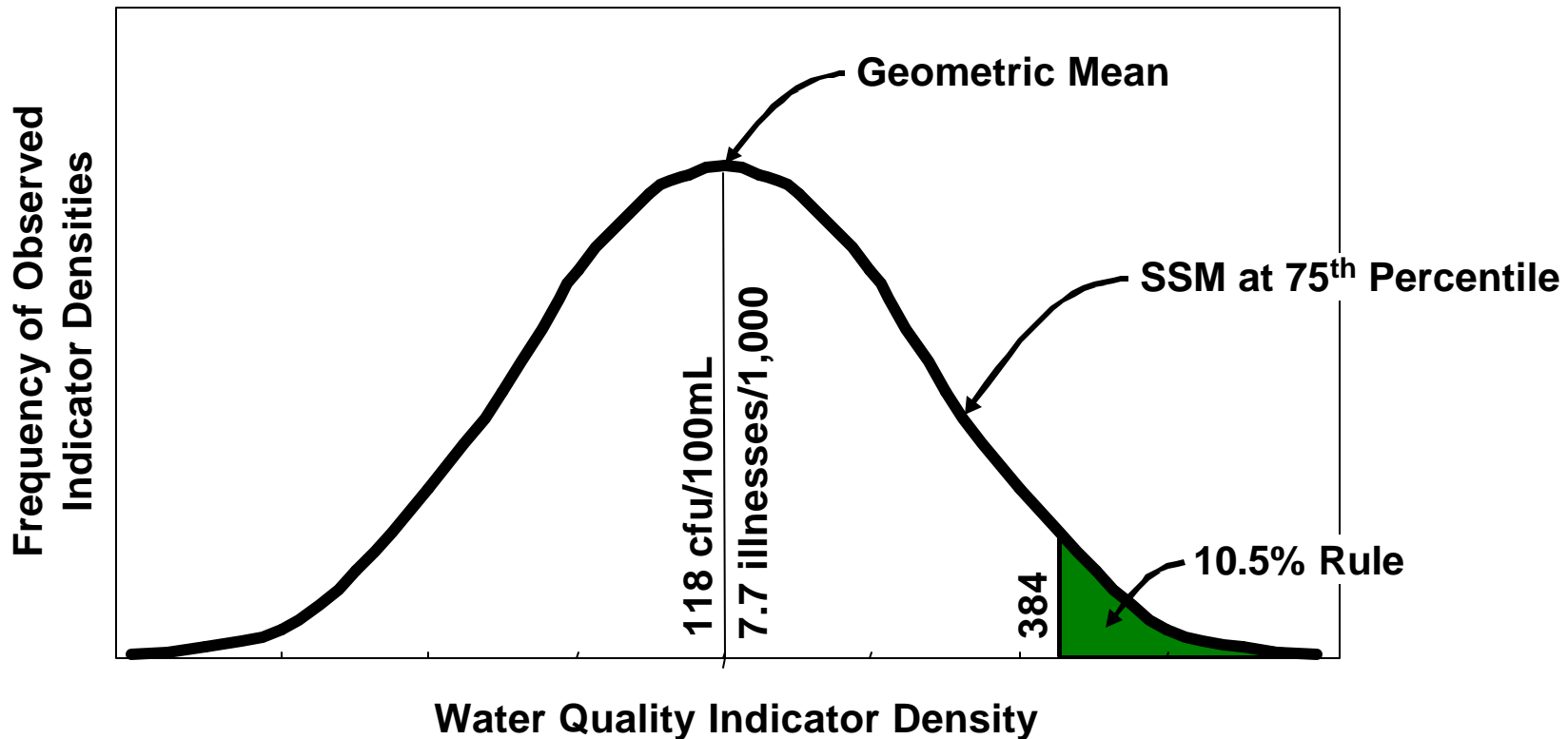




Use of Single Sample Maximum

Example with Freshwater 0.4 Log Standard Deviation

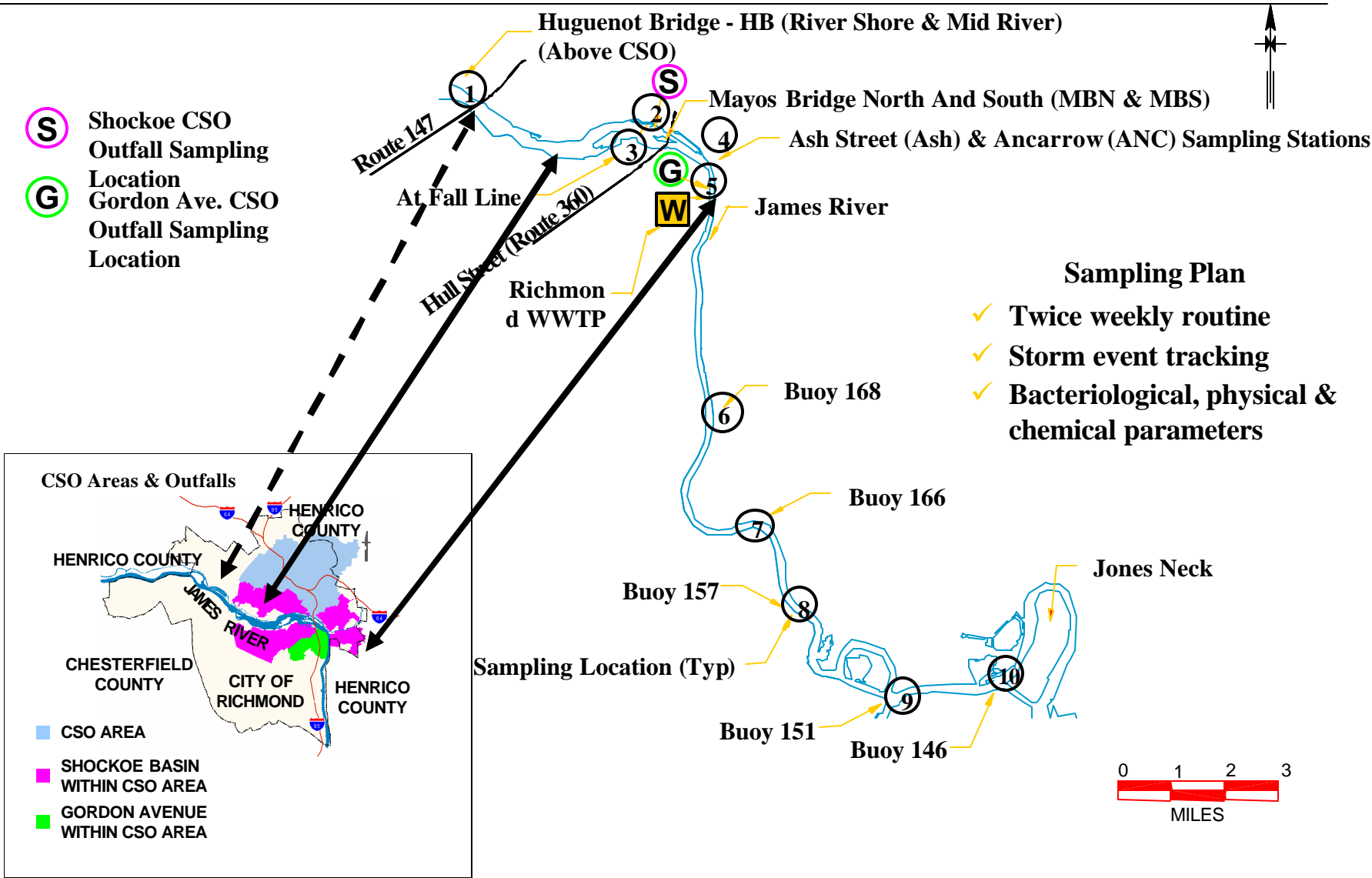
Distribution Around Mean





Richmond CSO Program

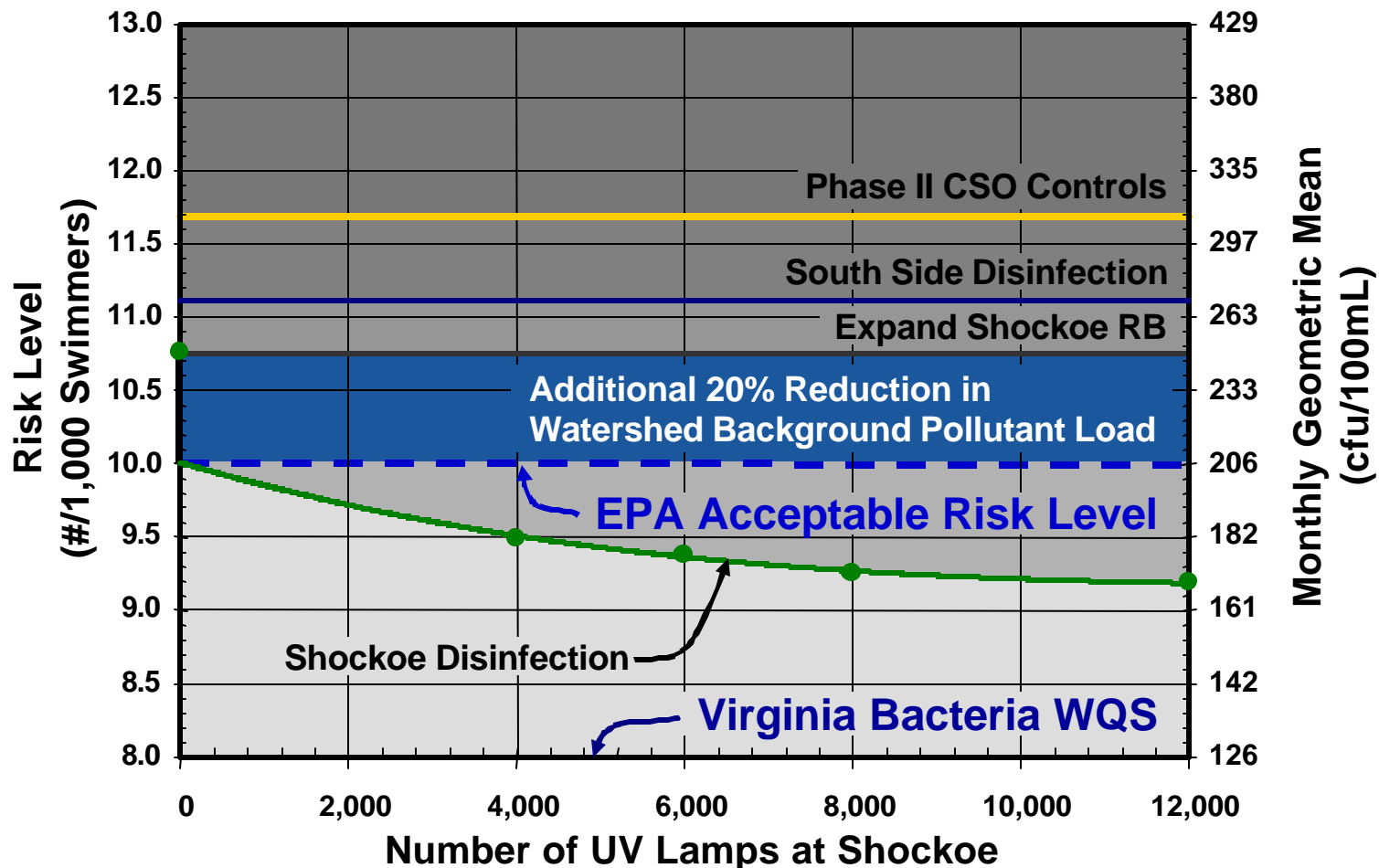
James River Monitoring





Shockoe UV Facility Performance

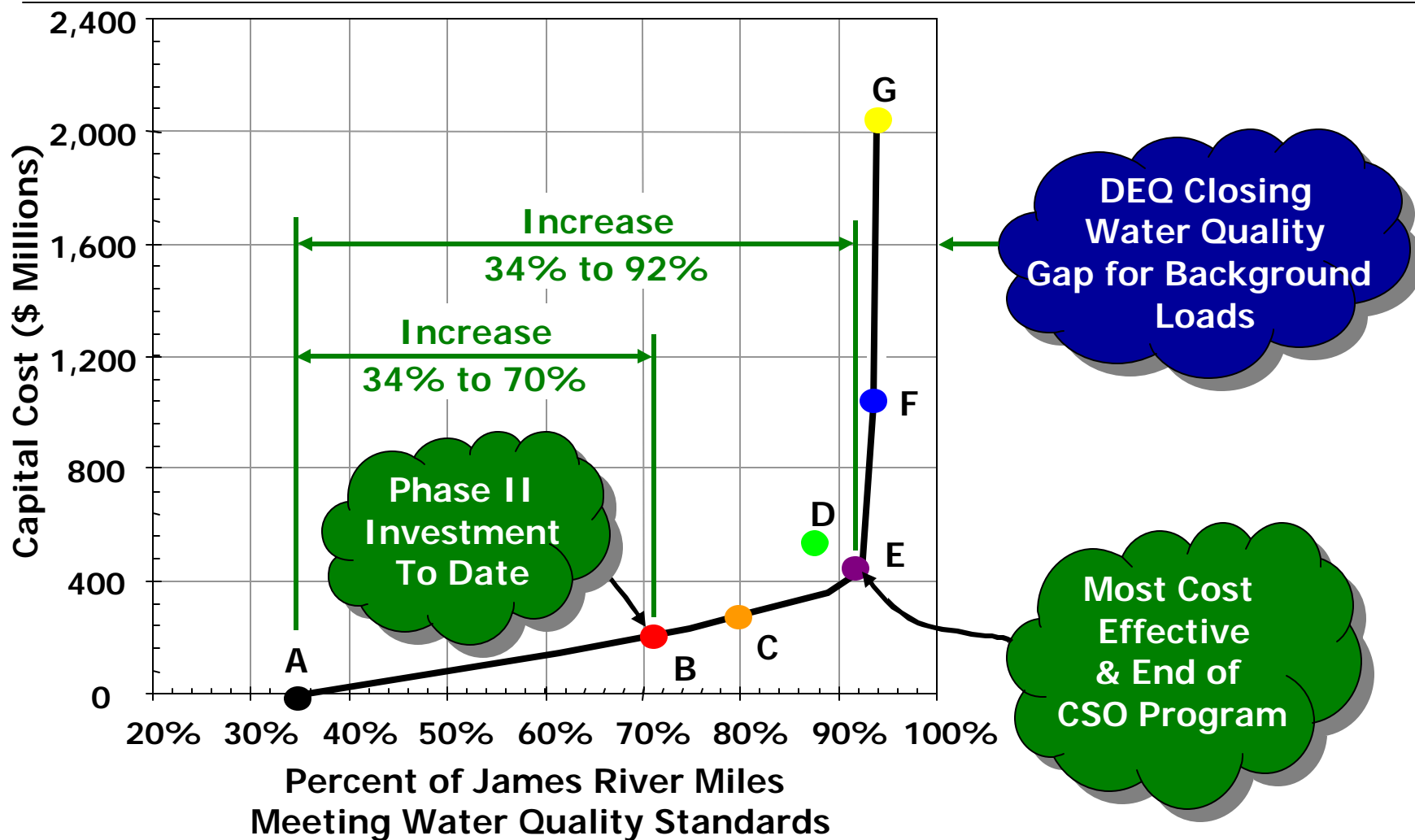
James River Reach 13 for August





Water Quality Standards Coordination

Percent of James River Miles Meeting Fecal Coliform WQS

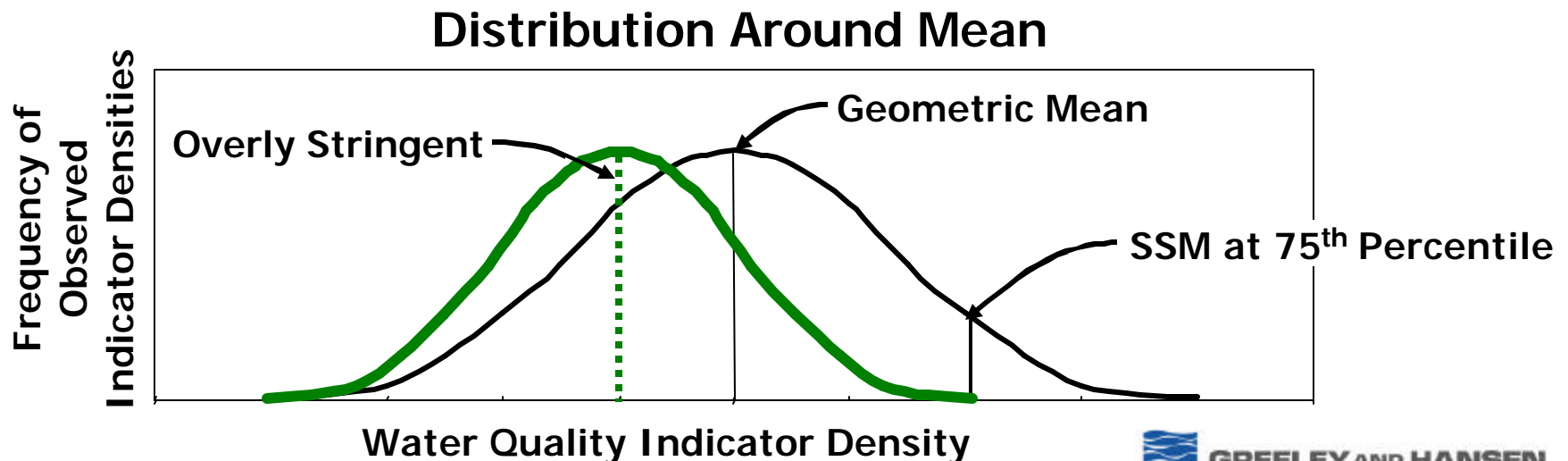




Water Quality Standards for Coastal and Great Lakes Recreation Waters; Final Rule (Beach Act 11/16/2004)

"3. Use of the Single Sample Maximum"

"Based on the derivation of the single sample maximums as percentiles of a distribution around the geometric mean, using the single sample maximums as values not to be surpassed for all Clean Water Act applications, even when the data set is large, could impart a level of protection much more stringent than intended by the 1986 bacteria criteria document."

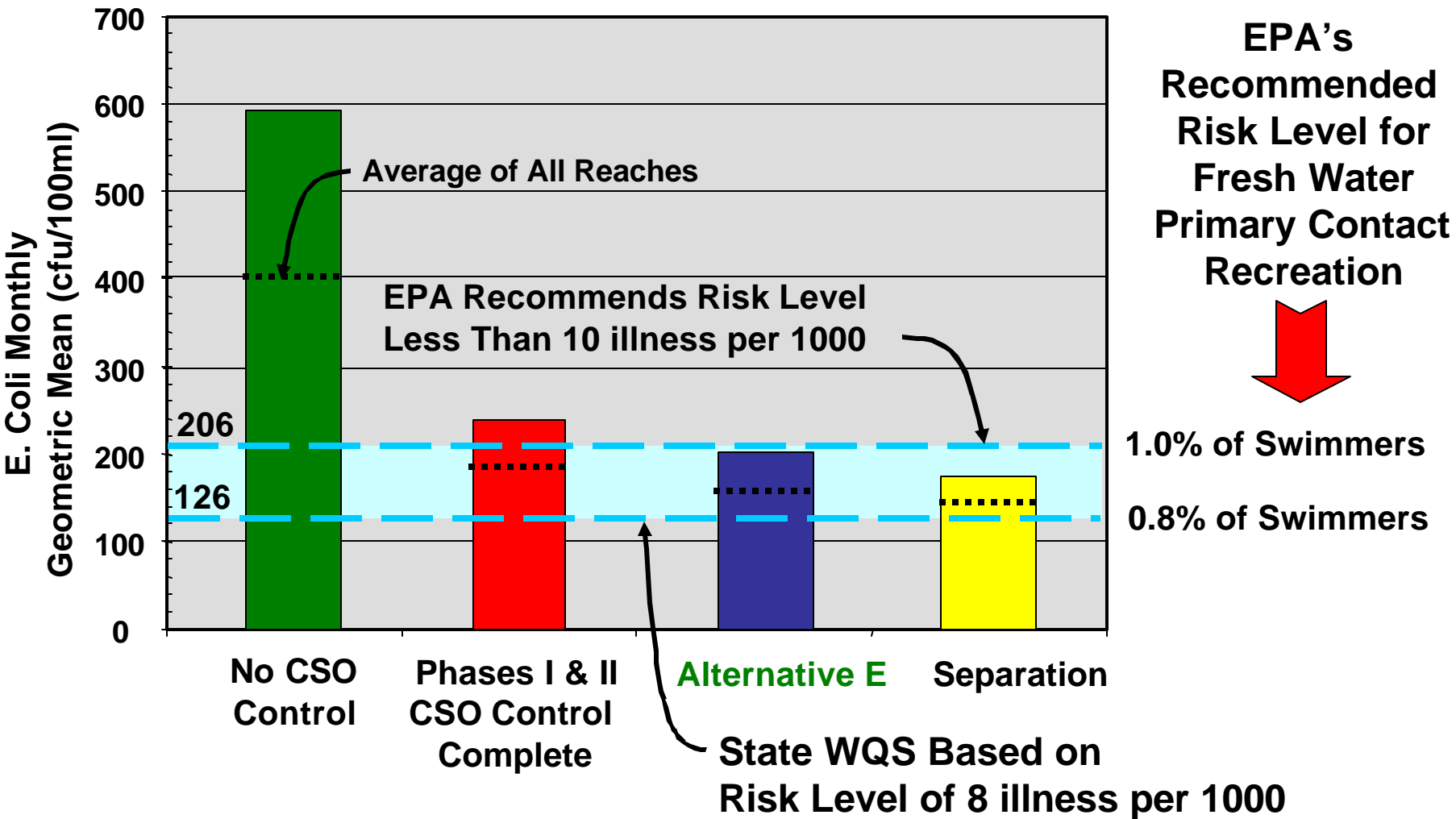




Richmond CSO Control Program

Geometric Mean & Associated Risk Level

Maximum Month (August) for Reach 13

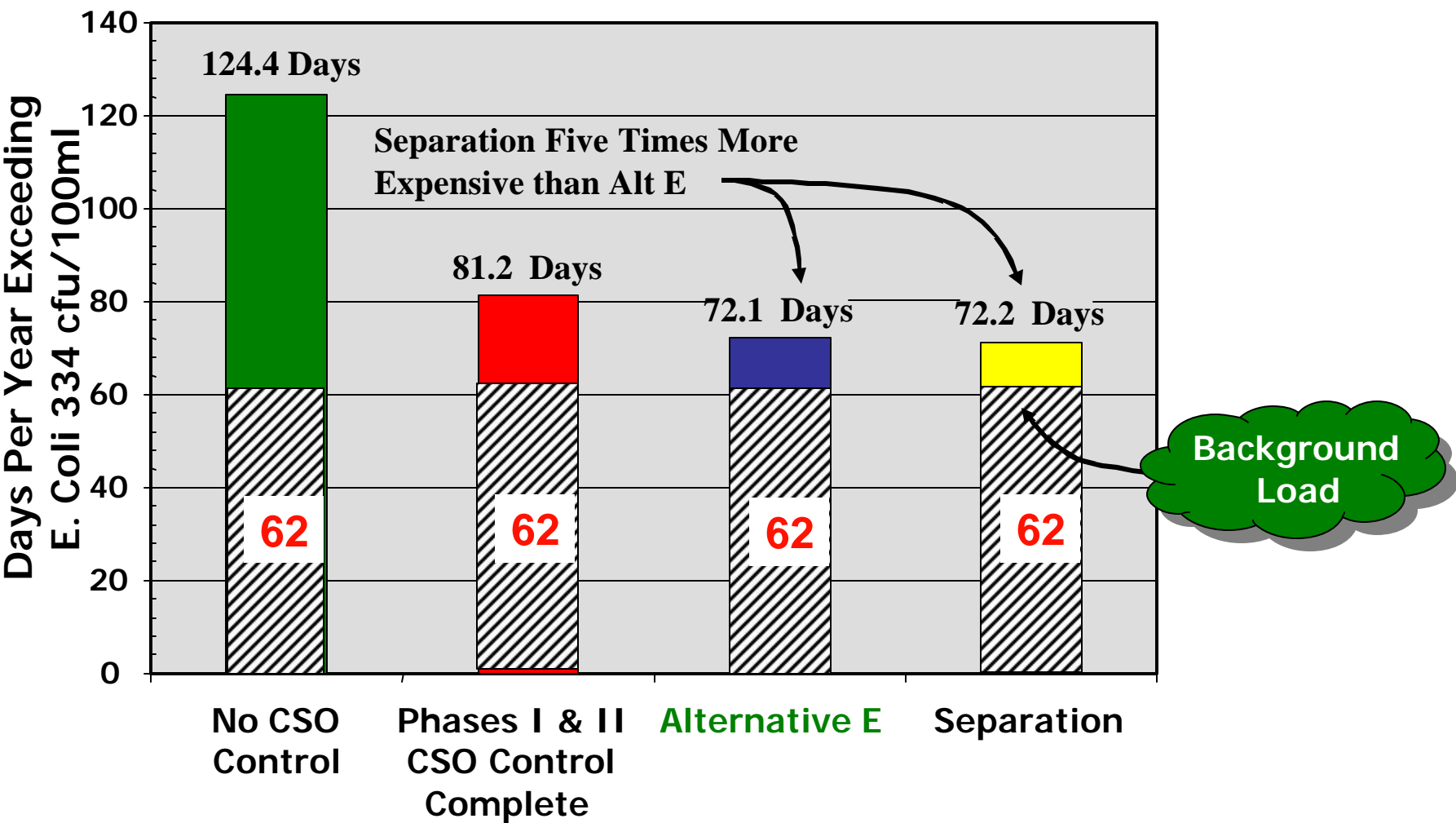




Richmond CSO Control Program

Average of River Reaches

Days Per Year Exceeding E. Coli 75th Upper Percentile Value





Richmond Area James River Bacterial TMDL

Wet Weather Issues

1. Use of Single Sample Maximum (*From EPA Beach Act 2004*)
 - “EPA recognizes that the **single sample maximum** discussion in the 1986 bacteria criteria document **refers only to beach monitoring**, and does **not** discuss how or whether the single sample maximum should be implemented for other Clean Water Act applications, such as establishing Total Maximum Daily Loads or National Pollutant Discharge Elimination System permit limitations.”
 - “Other than in the beach notification and closure decision context, **the geometric mean is the more relevant value for ensuring that appropriate actions are taken to protect and improve water quality because it is a more reliable measure, being less subject to random variation, and more directly linked to the underlying studies on which the 1986 bacteria criteria were based.**”
2. EPA Established Freshwater Risk Levels (i.e. 8, 9 and 10 illnesses per 1,000 swimmers)
 - Freshwater Inconsistent with Risk Level for Coastal Beaches at 19 illness per 1,000 swimmers
3. If 1. & 2. above are not Addressed before setting WLAs, the TMDL may not be achievable
 - Timing Issue with Triennial Review

